Emergency Imaging in Vulnerable Populations: The Pediatric Patient

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How are Children Vulnerable?

• Unable to communicate effectively
• Unable to understand instructions and cooperate
• Pathologies differ from adults
• Unexpected conditions or misleading histories
• Higher risk with radiation exposure
Objectives

• Recognize the special challenges and risks of emergency imaging in pediatric patients
• Understand how patient age determines optimal choices for imaging modality and technique
• Avoid pitfalls in interpretation of imaging studies in children with emergency conditions and injuries

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Risk of Medical Radiation in Children

- Organ sensitivity, larger dose/body area, longer life span
- Use of radiation-based imaging studies
  - At least 1 study in 40% of children (during 3 yrs)
  - CT
    - 11% of all CT exams performed on children
  - Radiography
    - 85% of all exams (2% of total radiation dose)
    - Potentially increased with digital XR
  - Fluoroscopy
    - 2% of exams
    - Dose highly variable

Potential risk of higher radiation exposures in children highly publicized
Use of CT and Cancer Risk

• Use is beginning to moderate
  • Increased by 2 to 3 times from 1996-2005
  • Stable from 2005-2007
  • Decreased slightly from 2007-2010
• Studies with effective doses >20mSv (2001-11)
  • 14-25% of Abd/pelvis CT
  • 6-14% of spine CT
  • 3-8% of chest CT
• Risk of solid tumor – 1/300-390 Abd/pelv
• Reducing highest 25% of doses could prevent 43% of radiation-induced cancers

Miglioretti, JAMA Pediatr online; June 2013
Minimizing Radiation Exposure

- Strategies for keeping dose low in children
  - Minimizing the extent of exposure
    - Collimation
    - Positioning
    - Shielding
    - No grid for parts less than 10-12 cm in thickness
  - Using lower dose techniques
    - Raising tolerance for image noise
  - Consider using alternative imaging modalities

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**Advice for Decreasing Dose in Pediatric CT**  
Goske et al, AJR (2008)

- “Child-size” your CT (kVp, mA)
  - Pediatric protocols on IG website ([www.imagegently.org](http://www.imagegently.org))
  - Lower dose protocols for certain body regions
    - Chest
    - Skeleton
    - Paranasal sinuses
  - Indications
    - Renal stones
    - Shunt malfunction

- Lowering dose
  - Low dose localizer, decreased tube current or voltage, increased pitch, scan length, iterative reconstruction

Many resources to help child-size your pediatric protocols
Advice for Decreasing Dose in Pediatric CT

• Scan only when necessary
  • Must develop better definitions of “necessary”
  • PECARN Head CT decision rule (children< 2 yrs)
    • Normal mental status
    • No scalp hematoma (except frontal)
    • No LOC > 5 secs
    • Non-severe injury mechanism
    • No palpable skull fracture
    • Acting normally according to parents
• NPV=100%, sensitivity 100%

Kupperman, Lancet 2009; 374: 1160–70
CT for Pediatric Chest Trauma

- CT will identify more pathology than CXR
  - Contusion/consolidation – 77% vs. 42%
  - Pneumothorax – 33% vs. 7%
  - Rib fracture – 21% vs. 4%
  - Mediastinum (nonvascular) – 10% vs. 2%
- Conditions requiring intervention are virtually all visible on based on CXR
  - Occult pneumothoraces on CXR rarely need tube therapy
    Holscher et al, J of Surg Research 184(2013): 352-357
    Lee et al, Acad Emerg Med (2014) 21:440-448
- CT indicated with high risk mechanism, abnormal CXR
- CT not necessary when CXR is normal
Advice for Decreasing Dose in Pediatric CT

• Scan only the indicated region
  • Requires point of care protocoling
• Scan only once
  • Delayed imaging for trauma scans should be restricted to those cases with high risk injuries on initial pass images

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Dose Reduction in Digital Radiography

• Why worry about radiography?
  • 85% of ionizing radiation exams in children
  • Avg. child will have 7 XR exams by age 18

• Digital radiography can lead to increasing radiation dose
  • Caused by lack of direct visual feedback

**Digital imaging (CR/DR):** Equipment compensates for overexposure; film appears to be properly exposed

A. Underexposure
B. Optimal
C. Overexposure

Exposure Creep in DR

• Emergency Care Research Institute 2015 list of top healthcare hazards
  • Exposure creep in digital radiography #7
    • Loss of immediate feedback about overexposure
    • Excessive exposure reduces noise, image looks better
    • Technologists will err on side of overexposure
    • Can lead to progressively increased exposures
  • Attention to exposure indices, better defined pediatric techniques are needed

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Alternative Imaging Modalities

• Ultrasound an effective screening study for many clinical problems
  • Hypertrophic pyloric stenosis
  • Intussusception
  • Appendicitis

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Experience Counts in Ultrasound

False positive - stomach was not distended with fluid

False negative – GE junction mistaken for pylorus
Appendicitis

• Presenting symptoms in children differ from adults:
  • No migration of pain in >50% of children
  • No anorexia in > 50% of children
  • No rebound tenderness in > 50% of children
  • Time course of pain commonly less than 24 hours
  • Diarrhea is not uncommon
  • Pain often poorly localized
US for Appendicitis

- Still accepted as best first screening exam
- Staged approach using CT for equivocal cases highly accurate
  - Sensitivity 98.6%
  - Specificity 90.6%
  - CT avoided in 53%

Krishnamoorthi, Radiol Jan. 2011
Thickened Echogenic Fat = Inflammation

Absent peristalsis in RLQ = adynamic ileus

Complex free fluid = peritonitis

Secondary findings can be important clues when the appendix is not visible on US
CT very good but not ideal in young children

- Lack of intra-abdominal fat

Johnson, AJR, Jun 2012; 198:1424
Moore, Pediatr Radiol, Mar 2012; 42:1056
Herliczek, AJR, May 2013; 200: 969

Ultrafast MRI as good or better for some children
Differences in Pathology from Adults

- Infection, trauma, congenital/developmental abnormalities common
  - Neoplasms, vascular disease, chronic conditions uncommon
- Anatomical differences mimic pathology
RSV Infection
Viral Infection with Atelectasis
Unexpected Conditions

- Common in young children with poor ability to communicate problems
Foreign Object Ingestion/Aspiration

- Often unwitnessed
- Non-specific presenting symptoms
  - Cough
  - Wheezing

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Peanut in L bronchus

Esophageal foreign bodies don’t cause major airway obstruction
Expiratory radiographs can show air-trapping that is subtle on inspiratory views

- Worthwhile whenever the history suggests aspiration
Aspiration Pneumonitis with Toxin Ingestion

- Hydrocarbon ingestion
  - Lamp oil
  - Lighter fluid
  - Ingestion often witnessed

- Lipoid pneumonia
  - Mineral oil for constipation
  - Suppresses cough reflex
  - Aspiration may not be suspected
Non-accidental Trauma

- Histories usually obscure or absent
- Injuries often subtle in young children
- False negatives and false positives common on skeletal imaging
  - Occult rib fractures in acute stage
  - Normal variants that resemble fractures
  - Uncertainty about timing/mechanism of detected fractures

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Acute rib fractures may not be visible until healing.
8 month old with vomiting and distended abdomen
Perforated jejunum in a battered child
Abdominal Trauma in the Battered Child

- 4-15% of abdominal trauma in children in U.S. is inflicted.
  - >25% of AT in infants is abusive
- >50% of these children are in critical condition when they present
  - Delay in bringing for care
  - Mortality rate – 13-45%
- Recognition of the injuries is often delayed in the ED
Differentiating Accidental from Non-Accidental

- Keep a high index of suspicion, but keep common accidental injuries in perspective

11 day old infant
Traumatic vs Non-traumatic Intracranial Hemorrhage

- Unexplained intracranial hemorrhages raise suspicion of NAT, but causes for non-traumatic brain hemorrhage exist:
  - Sinus thrombosis
  - Infection
  - Metabolic/clotting disorders
  - Stroke
- Evidence of trauma elsewhere in the patient tilts the scales toward NAT
- MRI may be helpful in some cases

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5 month old found non-responsive in crib

Bone survey normal
Points to Remember

• Use alternatives to CT, whenever sensible
  • US is great for many conditions, but is best when used by those experienced with pediatrics
  • MRI applications are growing in younger patients
• Keep CT doses low with child-sized protocols, single passes, arms over head
• Use patient age to help prioritize possible diagnoses, plan imaging
• Remember that histories can be misleading